Upscaling Above-ground Biomass Using Radar Remote Sensing Data

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Introduction

Analysis on impacts of landscape development on the environment at various scale levels could give better understanding on the variables that contribute to resultant event. In this context, information from various scale levels have to comprehensively compile in structured database that eventually allows further analysis be carried out. Using Pasoh Forest Reserve (PFR) as the main source of information, UTM research group with collaboration with Hiroshima University are conducting studies on impact of landscape development on ecological service values and good. Within this on-going study, mapping of the above-ground biomass has been one of the important issues due to high uncertainties within biomass dynamics in the tropical forest environment. Information regarding aboveground biomass (TAGB) at various levels, such as at macro, micro and even at landscape-scale is very much needed in understanding or minimizing these uncertainties. Radar remote sensing is often the only practical means in deriving information on forest biomass due to it capability of acquiring data in all-weather conditions, but has not been fully operationally used by forest mainly due to the lack of know-how on the processing of radar for deriving the required information. The processing requires one to understand the system and scene parameters apart from also capable to interpret the interaction of radar backscatters to the forest parameters. In this report we examines the upscaling of TAGB using synthetic aperture radar (SAR) data acquired using JERS-1 and Radarsat satellites. The estimation of forest biomass from both these SAR data were carried out using relationship of radar backscatters and TAGB derived from primary, secondary and fragmented forest plots in PFR (Hashim and Okuda, 2004). These plots were chosen to characterize homogeneous forest areas representing a range of ages of regeneration from new re-growth to mature forest. This report is part of the preliminary results of the on-going works for upscaling of ecology service values and goods covering the catchments of Pahang River and its tributaries which include PFR.

Methods

Satellite Remote Sensing Data

Two sets of multitemporal SAR data are used in study, namely: (i) JERS-1 SAR, and (ii) Radarsat SAR. Both data sets cover the entire Peninsular Malaysia, and the data specifications are tabulated in Table 1.

Table 1: SAR data specifications

	Data sets	
	JERS-1 SAR	RADARSAT SAR
Date of acquisition	1995-1996	2001
Spatial resolution	18m	100
Operating Wavelength	L band (23cm)	C band (6.8cm)
Total number of scenes	45	2
Data format	Level 1B	Scan SAR/ wide mode

Data processing

Figure 1 below illustrates the data processing undertaken in the study. Both the SAR data sets are subjected to data pre-processing to remove speckles and restore geometry of the data.

The relationship model of radar responses to TAGB have been previously examined (Hashim and Okuda, 2004) are used for extracting biomass at PFR. Assessments of these models were also carried out using independent mutual sets of plots collected by in-situ trees census of dbh>3cm. In-situ observation (trees census) are also employed to derive tagb based on allometric relationship (Kato *et al*, 1978) for the three study plots: 50ha primary forest, 6ha secondary forest and scattered fragmented forest, used in the assessments. Each primary and secondary plots were used to derived tagb at every grid of 20x20m, 50x50m and 100x100m, respectively.

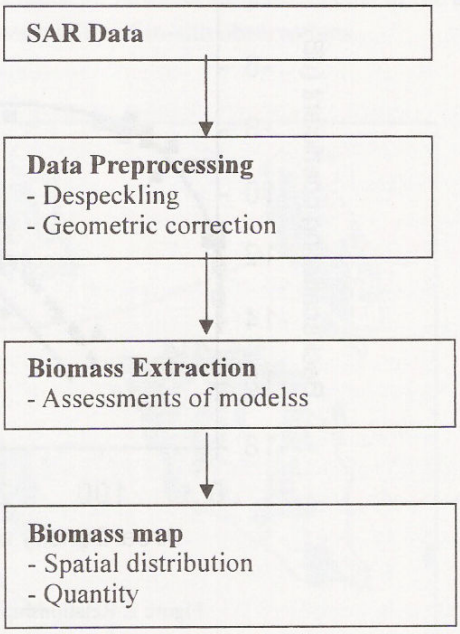

Figure 1: flow chart of the methods adopted in upscaling TAGB information

Results and Discussion

Preliminary results obtained are as follows:

1. Relationship of radar backscatters and TAGB is very spatial dependence. Best relationship shown by 20m grid, where the pixel size of jers SAR is 18m, given by Y = 6.0401 *Ln(x)* – 43.493, where Y is backscatter coefficient (dB), and x is TAGB measured (r^2=0.7, n=200, RMSE=24.7Mg/ha, p=0.0002)

2. Localized model for dense TAGB is needed. This is shown by the "saturation of the above relationship" for very high density TAGB area in PFR. Figure 2, illustrate these relationship. Similar result are also noted in on Luckman *et al* (1998); when SAR data are used to derived TAGB in dense TAGB of Amazon test site.

From the below SAR-TAGB relationship (Fig.2), we have then extracted the entire TAGB for all forested area under national forest inventory (2003) from JERS-1 SAR data. Comparing on the range of TAGB derived to in-situ observations obtained from previous studies carried in many part of Peninsular Malaysia (Table 2), it is noted that all derived TAGB fall within the observed. Further analysis on absolute accuracy of the derived upscaled TAGB is now being carried out using more samples gathered from various forest related agencies.

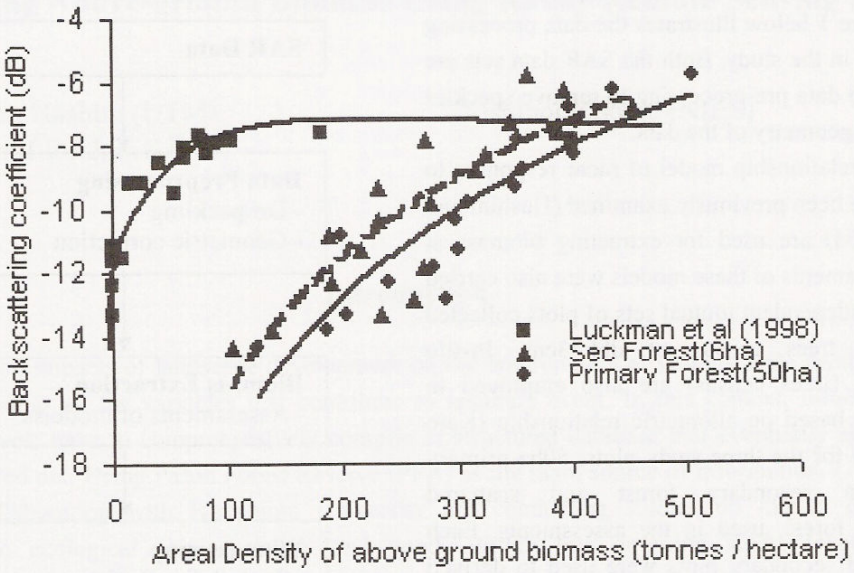

Figure 2: Relationship of SAR backscatter and TAGB in PFR

Table 2: Preliminary comparison of upscaled TAGB in selected forest in Peninsular Malaysia

Author	StudyArea	Biomass (Mg/ha)
Roland and Lim (1999)	Air Hitam Forest Reserve	83.69 – 232.39
Forestry Department (1987)	Selected moderate hill forest in Peninsular Malaysia	245 - 310
Kato *et al.* (1978)	Lowland forest, Pasoh Forest Reserve	80-475
Kira (1969)	Cameron Highland	288

Table 3: Preliminary amount of upscaled TAGB for all states in Peninsular Malaysia

	No of pixels at 20x20m	TAGB (x106) tonnes
Perlis	11241	4.5
Kedah	345847	123.1
Penang	9001	2.7
Perak	1109160	366
Kelantan	853700	300.3
Terengganu	666101	244.5
Selangor	289561	96.7
Pahang	2276021	835.3
Negeri 9	196819	72.4
Melaka	8299	2.7
Johor	580893	220.2

The distribution of and amount of TAGB derived from upscaled technique for the forested areas in all states in Peninsular Malaysia have also been obtained (see Figure 3), however the assessments of the absolute accuracy (Table 3) is yet to be determined pending on the availability of in-situ observations.

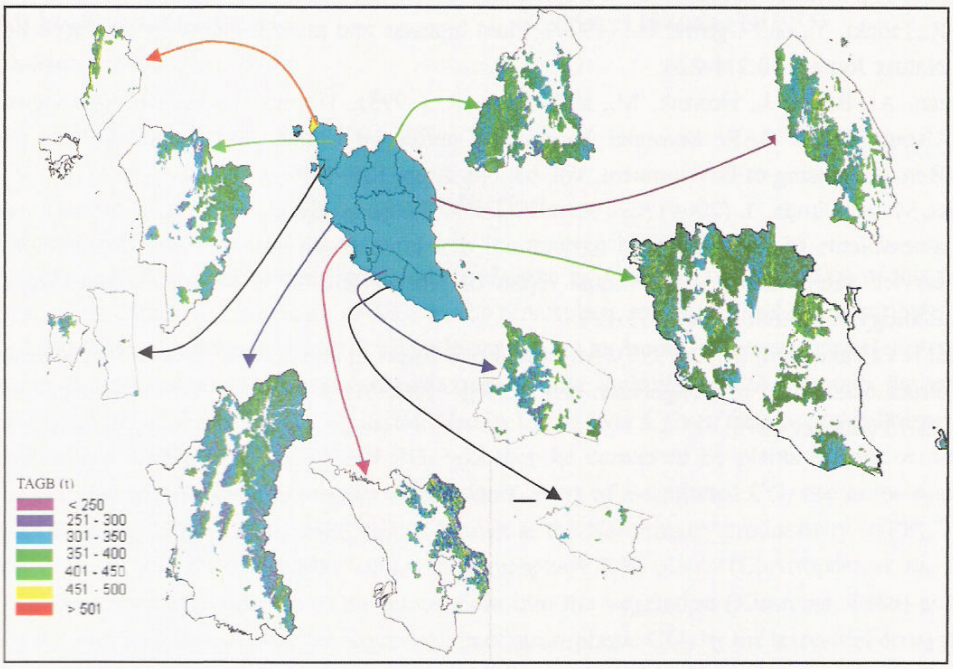

Figure 3: Upscaled TAGB derived from JERS-1 SAR data for forested areas in Peninsular Malaysia

Summary

Up-scaling selected biophysical parameters based on in-situ plots can be carried out using integrated Remote sensing, GIS together with appropriate ecological model at reasonable accuracy. Preliminary results on the upscaled total above ground biomass (TAGB) using plots in PFR have been demonstrated using JERS-1 SAR data. The relationship of TAGB and SAR data backscatters has shown best opportunity that SAR data as source of data for potential upscale approach at multi-temporal scales. Absolute assessment on the accuracy of the upscaled TAGB is yet to be determined at this point time. We also noted the localization effect of SAR data to record on the information particularly in the high density of TAGB, where saturation of backscatters occurred. These saturation can be overcome with use of finer mode of spatial resolution where the variation of density of TAGB within the finer pixels is lessen, hence enable the related parameters for deriving TAGB is enhanced. New generation of SAR data from the successfully launched Japanese SAR remote sensing, namely ALOS PALSAR is indeed very promising prospect to this task.

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